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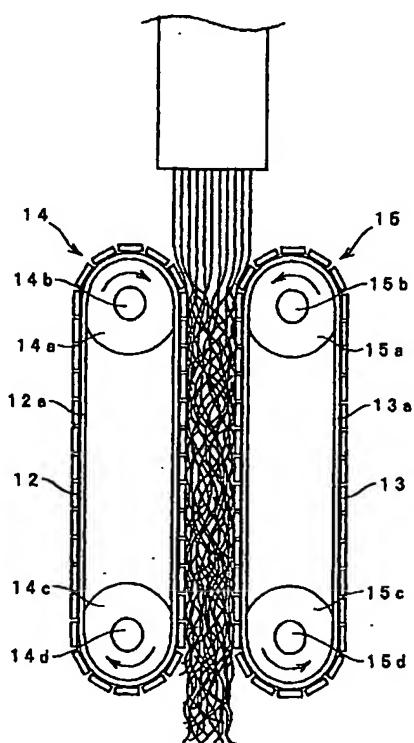
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London WC2B 6HP (GB)(54) **THREE-DIMENSIONAL NET-LIKE STRUCTURE, AND METHOD AND DEVICE FOR PRODUCING THREE-DIMENSIONAL NET-LIKE STRUCTURE**

(57) A method of and an apparatus for manufacturing a three-dimensional netted structure which is capable of rendering it unnecessary to carry out a finishing operation in a later stage, improving the degree of straightness of the side surfaces of the netted structure, meeting a demand for finishing the netted structure to modified shapes, and improving the durability of the netted structure. A three-dimensional netted structure (1) using thermoplastic resin as a raw material or a main raw material is characterized by a three-dimensional plate type netted structure, in which a plurality of filaments are helically and randomly entangled and partly and thermally bonded together. The density of any of at least three surfaces or four surfaces on the outer periphery of the three-dimensional netted structure is preferably relatively lower than the density of the other portion excluding these surfaces, and flaked or chipped PET bottles are used as a raw material or a main raw material for thermoplastic resin, such PET bottles being directly crushed and then melted to provide flakes, suiting to recycling promoting age, working well in waste disposal cost reduction, the uses of the three-dimensional netted structure (1) including, chiefly, shock absorbing materials, cushioning materials, and sound-absorbing materials.

FIG. 6





(12)

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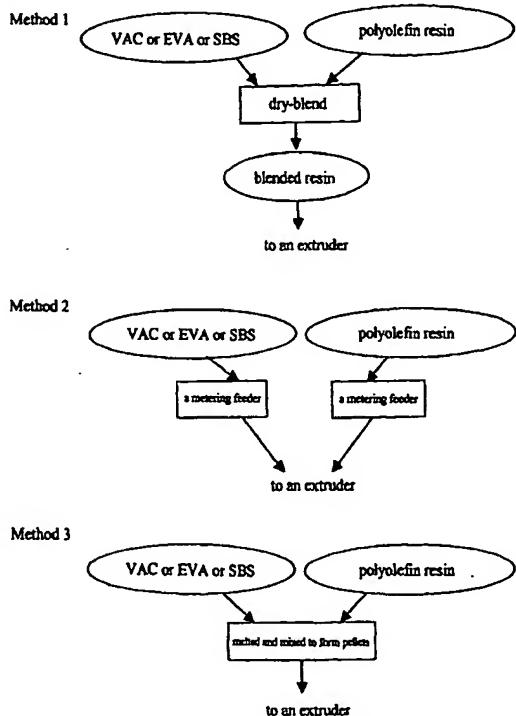
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**(54) Resin molded article having a spring structure and method of producing this resin molded article**

(57) There is provided a molded article which has high shock absorbing capability and load capacity. A resin molded article having a spring structure comprises a three-dimensional structure with voids, which is

formed by entwining and gathering adjacent ones of random loops or curls of solid and/or hollow continuous filaments and/or short filaments made from a mixture of a polyolefin resin and VAC, EVA or SBS.

FIG. 1



**Description****BACKGROUND OF THE INVENTION**5   **1. Field of the Invention**

[0001] This invention relates to a resin molded article with a spring structure and a method of producing the same, and more particularly to a resin molded article with a spring structure, which is excellent in shock resistance and load capacity and is also suitable for use as a filter medium, and a method of producing the same.

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## 2. Description of the Related Art

[0002] At present, a polyurethane foam is a mainstream material of cushions for seats and beds.

[0003] Further, a cushion has been proposed in Japanese Laid-Open Patent Publication (Kokai) No. 2000-51011, which is produced by partially bonding synthetic fibers and natural fibers of 1 to 20 deniers with each other, by a synthetic rubber adhesive.

[0004] Still further, a seat cushion pad for an automotive vehicle has been disclosed in Japanese Patent No. 2995325, in which a seat surface part is formed of a high resilience foam having a one layer structure, and the high resilience foam is made of a polyurethane foam which contains 10 wt% or less of tolylene diisocyanate (TDI), and the remainder isocyanate formed by diphenylmethane diisocyanate.

[0005] Generally, polyurethane foams sink deeply, and the user gets fatigued if he sits thereon for a long time. Further, it is difficult to recycle the polyurethane foams since they are thermoset resins. Therefore, polyurethane foams can only be recycled by crushing them into chips by a crusher, and bonding the chips into a material called chip foam (ribbon dead foam), or just burned for recovery of thermal energy. The method of disposal of polyurethane foams includes landfilling and incineration. However, stable lands cannot be created by using polyurethane foams since they are low in bulk density and soft, and hence landfill sites suitable therefor are limited. Further, incineration of polyurethane foams causes much damage to incinerators, and generates toxic gases which are required to be eliminated at high costs. However, there has been no alternate material which has a performance as high as a polyurethane foam when used as a cushioning material for seats, beds, etc. and which can be manufactured at low costs.

[0006] Further, polyurethane foams are so flexible that when used for seat cushion pads for an automotive vehicle, they cause a user to have feelings of being heaved from below and being rocked. Therefore, long hours of driving causes the user to feel numb at feet and get much fatigued. In addition, polyurethane foams have the following problems to be solved:

35   Polyurethane foams are difficult to clean and recycle. An amine catalyst used in manufacturing the same is trapped in the foams thereof, causing bad smell.

[0007] A polyurethane foam has a heat storage property, and is liable to be stuffy, and there is a fear that if the polyurethane foam is exposed to intensive light for a long time, it may start to burn. Moreover, when burned, it generates gases of cyanogen, hydrogen chloride, and ammonia.

[0008] Although year 2020 is set to a deadline of abolition of use of CFCs substitute which is used as a foaming agent, there is not yet found an alternate agent that is more excellent in foaming performance than the CFCs substitute.

[0009] TDI (Tolylene Diisocyanate) which is an isocyanate normally used for producing soft polyurethane foams is a very harmful material and Notification No. 25 of the Ministry of Labor of Japanese Government prescribes that TDI should be used at a concentration of 0.005 ppm or less. In many actual manufacturing sites, thorough control of TDI is not carried out, causing damage to health of workers.

[0010] In the above-mentioned seat cushion pad for an automotive vehicle disclosed in Japanese Patent No. 2995325 is improved in the characteristics of the soft polyurethane foam, but has the drawbacks of polyurethane foams.

[0011] Although the cushion proposed in Japanese Laid-Open Patent Publication (Kokai) No. 2000-51011 offers advantages in that it has excellent air permeability and is cleanable, it suffers from disadvantages in that it has a low durability, a manufacturing method thereof is complicated, and a processing cost is remarkably high. Further, the rubber adhesive and a crosslinkable polyurethane are thermoset resins which are difficult to recycle, and since the cushion is not of a single composition, it is difficult to recycle the cushion.

[0012] A cushion disclosed in Japanese Patent No. 2548477 is produced by fusion-bonding high-melting polyester fibers with low-melting thermoplastic elastomers, and hence suffers from problems to be solved in that the cushion is difficult to recycle, a manufacturing method thereof is complicated, and a processing cost is remarkably high.

[0013] The invention has been made as a solution to the above problems, and an object thereof is to provide a resin cushion element with a spring structure which can be recycled, manufactured at reduced costs, and does not sink deep

so that it does not fatigue the user even after it is used for a long time, for being used in place of the polyurethane foam which is difficult to recycle and suffers from the problems described hereinabove even in the disposal thereof.

[0014] Further, the invention permits resins, such as PE and the like, which are regenerated for reusing thermoplastic resin vessels for packaging edible oil and waste agricultural plastic films, to be regenerated as articles with high added value. The resin cushion element with a spring structure according to the invention can be recycled as many times as required. Further, the cushion structure according to the invention is produced by using, as a material, a mixture of a polyolefin resin, such as PE and PP, and a vinyl acetate resin (hereinafter referred to as "VAC"), or an ethylene vinyl acetate copolymer (hereinafter referred to as "EVA"), or styrene butadiene styrene (hereinafter referred to as "SBS"), and another object of the invention is to provide a resin molded article with a spring structure, which is excellent in cushioning properties when used for a cushion of a bed or a seat. Further, still another object of the invention is to provide a method which is capable of manufacturing, by easy molding steps, a molded article which is high in the freedom of shaping thereof, and has desired physical properties, such as load withstanding strength (load capacity) and shock resistance and the like.

## 15 SUMMARY OF THE INVENTION

[0015] A resin molded article 30 having a spring structure according to the invention comprises a three-dimensional structure at a predetermined bulk density (hereinafter simply referred to as the "three-dimensional structure"), the three-dimensional structure being formed by contacting, entwining, and gathering adjacent ones of random loops or curls of continuous filaments and/or short filaments made from a mixture of a polyolefin resin and VAC, EVA or SBS.

[0016] This invention is also characterized in that the three-dimensional structure has voids providing low and high densities.

[0017] The mixture ratio of the vinyl acetate content of the polyolefin resin to VAC or EVA is 70 to 97 wt% to 3 to 30 wt%, preferably, 80 to 90 wt% to 10 to 20 wt%. If the VAC content is equal to or lower than 3 wt%, the impact resilience of the three-dimensional structure is low, whereas when the VAC content is equal to or higher than 30 wt%, the thermal characteristics of the structure are degraded.

[0018] The mixture ratio of the polyolefin resin to SBS is 50 to 97 wt% to 3 to 50 wt%, preferably, 70 to 90 wt% to 10 to 30 wt%. The polyolefin resin may be a regenerated resin.

[0019] The solid continuous filaments and/or short filaments have a diameter e.g. of 0.3 mm to 3.0 mm, preferably 0.7 to 1.0 mm, and the hollow continuous filaments and/or short filaments have a diameter of 1.0 mm to 3.0 mm, preferably 1.5 to 2.0 mm. Further, the three-dimensional structure has a bulk density e.g. of 0.001 to 0.2 g/cm<sup>3</sup>, preferably 0.02 to 0.1 g/cm<sup>3</sup>. Although it is possible to form the three-dimensional structure only by solid filaments or hollow filaments, if a mixture thereof is used, the mixture ratio of solid filaments to hollow filaments is e.g. 0 to 50 to 50 to 100. Further, if hollow filaments are used in a central portion of the structure, and covered with solid ones, a tactile impression can be increased.

[0020] The present invention relates to a cushion material for a seat of an automotive vehicle or a bed, for instance. When the bulk density of the three-dimensional structure is equal to or lower than 0.001 g/cm<sup>3</sup>, strength thereof is decreased. If the bulk density is equal to or higher than 0.08 g/cm<sup>3</sup>, it is impossible to reduce a weight thereof, and elasticity thereof is lost.

[0021] If the diameter of the filaments is equal to or smaller than 0.3 mm, sturdiness of the filaments is lost, and increased number of portions of the filaments are fusion-bonded to thereby reduce the void ratio of the three-dimensional structure. Inversely, if the diameter of the filaments is equal to or larger than 3.0 mm, the filaments are excessively sturdy, and hence loops or curls are not formed, so that reduced number of portions of the filaments are fusion-bonded to thereby decrease the strength of the three-dimensional structure. The diameter of hollow filaments is 1.0 mm to 3.0 mm, preferably 1.5 mm to 2.0 mm. If the ratio of hollow filaments is equal to or smaller than 10 %, it does not contribute to reduction of the weight of the structure, whereas if the same is equal to or larger than 80 %, cushioning properties of the structure are degraded.

[0022] To maintain elasticity and strength of the structure as a cushion as well as reduce the weight thereof, the void ratio of the three-dimensional structure is required to be 91 to 99 %, preferably 93 to 96 %.

50

$$[\text{void ratio} (\%)] = (1 - [\text{bulk density}] / [\text{density of resin}]) \times 100$$

[0023] This invention further relates to a method of producing a resin molded article having a spring structure, by melt-extruding a polyolefin resin or a thermoplastic elastomer into a plurality of filaments, and contacting, entwining and gathering adjacent ones of random loops or curls of continuous filaments, thereby forming a three-dimensional structure with voids at a predetermined bulk density, wherein a take-off speed for taking off the extruded continuous filaments is changed to thereby form high density portions having an increased bulk density which each extend in a

direction of width of the three-dimensional structure and are arranged at appropriate space intervals in a direction of length of the three-dimensional structure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

- 5 [0024] The object and advantages of the invention will become understood from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings in which like names designate like elements, and in which:
- 10 FIG. 1 is a diagram schematically showing processes of manufacturing resin molded articles having a spring structure, according to an embodiment of the invention;  
 FIG. 2 is a diagram schematically showing an embodiment of an apparatus for implementing the method according to the invention;  
 FIG. 3 is a diagram schematically showing another embodiment of the apparatus for implementing the method according to the invention;  
 FIG. 4 is a diagram schematically showing still another embodiment of the apparatus for implementing the method according to the invention;
- 15 FIG. 5 is a graph showing a load-compression deflection ratio according to Example 1;  
 FIG. 6 is a graph showing a load-compression deflection ratio according to Example 2;  
 FIG. 7 is a graph showing a load-compression deflection ratio according to Example 3;  
 FIG. 8 is a graph showing a load-compression deflection ratio according to Example 4;  
 FIG. 9 is a graph showing a load-compression deflection ratio according to Example 5;
- 20 FIG. 10 is a graph showing a load-compression deflection ratio according to Example 6;  
 FIG. 11 is a graph showing a load-compression deflection ratio according to Example 7;  
 FIG. 12 is a graph showing a load-compression deflection ratio according to Example 8;  
 FIG. 13 is a graph showing a load-compression deflection ratio according to Example 9;
- 25 FIG. 14 is a graph showing a load-compression deflection ratio according to Example 10;  
 FIG. 15 is a graph showing a load-compression deflection ratio according to Example 11;  
 FIG. 16 is a graph showing a load-compression deflection ratio according to Comparative Example 1;
- 30 FIG. 17 is a graph showing a load-compression deflection ratio according to Comparative Example 2;  
 FIG. 18 is a graph showing a load-compression deflection ratio according to Comparative Example 3; and  
 FIG. 19 is a graph showing a load-compression deflection ratio according to Comparative Example 4;.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

- 35 (Three-dimensional Structure)
- [0025] A three-dimensional structure employed in the invention has voids and is formed of continuous filaments and/or e.g. short filaments that are randomly entwined and gathered. The continuous and/or short filaments form a plurality of loops or curls. The above three-dimensional structure can be formed as follows: A thermoplastic resin, such as polyethylene, for instance, and VAC, EVA or SBS are metered and mixed using a tumbler or a cutting feeder. The mixture is subjected to melt-extrusion at a predetermined speed through a plurality of nozzles, taken off by a winder, referred to hereinafter, and formed into solid and/or hollow continuous filaments of 600 deniers to 90,000 deniers, preferably 3,000 deniers to 30,000 deniers, more preferably 6,000 deniers to 10,000 deniers. The filaments in a fused state are caused to form loops having a diameter of 1 mm to 10 mm, preferably 1 mm to 5 mm, and are taken off by the winder within water while bringing adjacent ones of the filaments into contact with each other within the water to be entwined forming random loops. In taking off the filaments, the take-off speed of the winder is adjusted to a low take-off speed by the winder at intervals of e.g. 3 to 5 m such that there is formed a three-dimensional spring structure with a thickness of 10 mm to 200 mm and a width of 2,000 mm, the three-dimensional spring structure having high-density portions having a high bulk density with a length of 30 cm to 50 cm in a longitudinal direction formed when the extruded material is received at the low take-off speed and low bulk density portions other than the high density portions. The contacted and entwined portions of the filaments are at least partially fused and bonded to one another.
- [0026] The continuous and/or short filaments are preferably made of a thermoplastic elastomer, e.g. an elastomer of polypropylene, polyester, nylon or PVC.
- 55 [0027] The three-dimensional structure can be formed such that it has low density portions and high density portions in bulk density as required. The bulk density at the low density portions is 0.005 to 0.03 g/cm<sup>3</sup>, preferably 0.008 to 0.03 g/cm<sup>3</sup>, particularly preferably 0.01 to 0.03 g/cm<sup>3</sup>, while the bulk density at the high density portions is 0.03 to 0.08 g/cm<sup>3</sup>, preferably 0.04 to 0.07 g/cm<sup>3</sup>, particularly preferably 0.05 to 0.06 g/cm<sup>3</sup>.

[0028] The void ratio of the three-dimensional structure at the low density portions is 96 to 99 %, preferably 97 to 99 %, and particularly preferably 97 to 98 %, while the void ratio at the high density portions is 91 to 97 %, preferably 92 to 96 %, and particularly preferably 93 to 94 %.

5 (Manufacturing Method)

[0029] In the method of producing the resin molded article 30 having a spring structure, according to the invention, will be described. It is preferable that resin materials are dry-blended with each other by a tumbler, referred to hereinafter, or a metering feeder, or mixed or melted and mixed with each other to form pellets, followed by being fed to a hopper of an extruder.

[0030] Resin materials, e.g. polyethylene and SBS were blended with each other by a tumbler (KR blender made by Katoriki Seisakusho) at 40 rpm for 15 minutes (FIG. 1).

[0031] The above mixture was fed into a  $\phi$ 65 mm uniaxial extruder 10 via a hopper 11 thereof, and taken off at 60 rpm at a take-off speed of 1.0/min. Resins were melted and kneaded at a temperature of 200°C for Examples 1 to 6, and at a temperature of 260°C for Examples 7 to 9, and extruded through a lot of injection ports formed in a molding die 12 and having a predetermined diameter. More specifically, the mixture is subjected to melt extrusion at a predetermined speed through a plurality of nozzles, taken off by the winder, referred to hereinafter, and formed into solid or hollow continuous filaments having a predetermined diameter. The filaments in a fused state are caused to form loops, and are taken off by the winder within water while bringing adjacent ones of the filaments into contact with each other within the water so as to be entwined forming random loops. When taking off the filaments, the take-off speed of the winder is adjusted to a low speed at predetermined intervals. For instance, if the take-off speed of the feed rollers 14 and 14 of the winder is adjusted to a low speed for a preset time period from each preset time by using a timer or the like, it is possible to obtain the resin molded article 30 having a spring structure with high and low density portions, which includes high bulk density portions with a predetermined length in the direction of the length thereof at predetermined space intervals. That is, the resin molded article 30 having a spring structure can be manufactured by forming a three-dimensional spring structure, referred to hereinafter, which includes the high bulk density portions (high density portions B) formed when the take-off speed is low, and the other low density portions (low density portions A) (FIG. 2). The taken-off material randomly curled or looped is solidified in the water in a bath 15 and taken up by take-up rollers 16 and 16, to provide the resin molded article 30 having a spring structure. The thickness and bulk density of the extruded material are set between the feed rollers 14 and 14 of the winder 13 in the bath 15. When the material is taken off, it is sometimes difficult to bend it by the feed rollers 14 and 14. To eliminate this inconvenience, by forming still lower density portions than the low density portions, the material is bent at the still lower density portions and drawn out of the water. (FIG. 3).

[0032] FIG. 4, shows a cutting device arranged in the bath 15 for cutting the molded form. The cutting device 19 is positioned in the vicinity of the winder 13 at a location downward thereof. Arranged at an inner wall of the bath 15 opposed to the cutting device 19 is a transport device 11 comprised of a conveyer having a lot of engaging projections for insertion into voids of each single molded form cut off at a cutting portion. In the figure, reference numerals 25 and 26 designate a water supply valve and a drainage valve, respectively (FIG. 4). The filaments are randomly curled or looped, solidified in the water in the bath 15 and taken up by the take-up rollers 16 and 16, as the resin molded article 30 having a spring structure.

[0033] As described above, the resin molded article 30 having a spring structure is obtained which has, for instance, a thickness of 30 mm and includes a high density portion with a length of 30 cm after every low density portion having a length of 3 m.

[0034] The resin molded article 30 having a spring structure can be manufactured by using the above-mentioned three-dimensional structure which includes one type of property or a combination of a plurality of types of properties different from each other.

Examples

50 Examples of molded products which are different in compounding ratio between resin materials

[0035] Examples of spring structures were produced by using combinations of resin materials PE + VAC, PE + EVA, and PP + SBS, while varying the compounding ratio of each of the combinations.

[0036] The compounding ratios, manufacturing conditions, and characteristic values, such as bulk density, are shown in Table 1, Table 2, and Table 3, respectively.

55 Examples 1 to 3: PE + VAC

Examples 4 to 6: PE + EVA

Examples 7 to 9: PP + SBS

Table 1

Compounding ratios in Examples 1 to 9					
	PE(wt%)	PP(wt%)	VAC(wt%)	EVA(wt%)	SBS(wt%)
Example 1	95		5		
Example 2	90		10		
Example 3	70		30		
Example 4	89			11	
Example 5	78			22	
Example 6	34			66	
Example 7		95			5
Example 8		90			10
Example 9		70			30

Table 2

Manufacturing conditions of Examples 1 to 9		
Molding die	Discharge rate	Take-off speed
300 mm(W) X 50 mm(T)	28 kg/h	1.0 m/min

Table 3

Characteristic values of Examples 1 to 9			
Bulk density	Diameter	Area	Thickness
0.03 g/cm <sup>3</sup>	1.5 mm (hollow)	300×300 mm	50 mm

Examples of manufactured products which are different in bulk density

[0037] Spring structures changed in bulk density were produced from resin materials having the same compounding ratio of PE : VAC = 90 : 10. The process of producing the spring structures will be described. The resin materials were blended by using a tumbler called KR blender (type: KRT-100) made by Katoriki Seisakusho, at 40 rpm for 15 minutes. The spring structures were molded by using the φ65 mm uniaxial extruder, and taken off at a screw rotational speed of 60 rpm, and at take-off speeds of 3.1 m/min. and 0.6 m/min. The temperature of the resins was 200°C.

[0038] The compounding ratios between the resin materials, manufacturing conditions, and characteristic values, such as bulk density, are shown in Table 4, Table 5, and Table 6, respectively.

Examples 10 and 11 (PE + VAC)

Table 4

Compounding ratios in Examples 10 and 11		
	PE(wt%)	VAC(wt%)
Example 10	90	10
Example 11	90	10

Table 5

Manufacturing conditions of Examples 10 and 11			
	Molding die	Discharge rate	Take-off speed
Example 10	300 mm(W)×(T)	28kg/h	3.1m/min
Example 11	300 mm(W)×(T)	28kg/h	0.6m/min

Table 6

Characteristic values of Example 10 and 11				
	Bulk density	Diameter	Area	Thickness
Example 10	0.01 g/cm <sup>3</sup>	1.5 mm (hollow)	300×300 mm	50 mm
Example 11	0.05 g/cm <sup>3</sup>	1.5 mm (hollow)	300×300 mm	50 mm

## Comparative Examples

## Polyurethane foam

[0039] A soft polyurethane foam which is a mainstream material for a cushion element was prepared as Comparative Example 1. The manufacturing conditions and product characteristics of the soft polyurethane are shown in Table 7.

## Comparative Example 1 (polyurethane foam)

[0040]

Table 7

Main raw material and manufacturing conditions of Comparative Example 1	
Molding method	Cold mold foam
Polyol type	Polyether polyol (terminal 1st class-OH)
functional group number	3
molecular weight	4500-6000
Foam stabilizer	Low-activity silicon foam stabilizer
Isocyanate	TDI-80
Foaming machine	Foaming machine for few ingredient (2 to 3)
Die temperature during injection	50°C
during mold release	50°C
curing time	14 min.

## Conventional spring structure

## PP (non other composition is added).

[0041] Spring structures were produced only from the resin material PP by varying the bulk density.

[0042] The spring structures were molded by using the φ65 mm uniaxial extruder, and taken off at a screw rotational speed of 60 rpm, and at take-off speeds of 0.6 m/min, 1.0 m/min and 3.1 m/min. The temperature of the resin was 260°C. The compounding ratios, manufacturing conditions, and characteristic values, such as bulk density, are shown in Table 8, Table 9, and Table 10, respectively.

Comparative Examples 2, 3, and 4 (only PP)

[0043]

5 Table 8

Compounding ratios of Comparative Examples 2 to 4	
	PP (wt%)
Comparative Example 2	100
Comparative Example 3	100
Comparative Example 4	100

15 Table 9

Manufacturing conditions of Comparative Examples 2 to 4			
	Molding die	Discharge rate	Take-off speed
Comparative Example 2	300 mm(W) × 50 mm(T)	28 kg/h	3.1m/min.
Comparative Example 3	300 mm(W) × 50 mm(T)	28 kg/h	1.0m/min.
Comparative Example 4	300 mm(W) × 50 mm(T)	28 kg/h	0.6m/min.

25 Table 10

Characteristic values of Comparative Examples 2 to 4				
	Bulk density	Diameter	Area	Thickness
Comparative Example 2	0.01 g/cm <sup>3</sup>	1.5 mm (hollow)	300 mm × 300 m	50 mm
Comparative Example 3	0.03 g/cm <sup>3</sup>	1.5 mm (hollow)	300 mm × 300 m	50 mm
Comparative Example 4	0.05 g/cm <sup>3</sup>	1.5 mm (hollow)	300 mm × 300 m	50 mm

35 Tests

[0044] In the tests, the following properties are revealed.

Test 1: Compression characteristic

Test 2: Residual distortion after repeated compression

Test 3: Impact resilience ratios

Test 1: Compression characteristics

[0045] The test was carried out in conformity with the JIS K 6400 soft polyurethane foam-testing method Appendix (reference) 1. The size of test pieces is 300 (W) X 300 (L) X 50 (T). Diagrammatic views showing load-compression deflection ratios are shown in FIGS. 5 to 19.

[0046] Cushion elements having a spring structure, which are all of Examples, and a polyurethane foam, which is Comparative Example, 1 are compared with each other. None of Examples have a noticeable yield point which is found in Comparative Example 1. This means that the cushion elements have a small quantity of local sinkage, thereby making it possible to uniformly receive load on a whole region in contact with a cushion structure.

[0047] Next, in Comparative Example 1, a rise of load is recognized when the deflection ratio exceeds 50 %, while such a rise is not recognized in any of Examples. Further, in all Examples, the three-dimensional structure can be effectively deformed up to about 90 % of thickness thereof. This shows that the structure does not provide a bottom touching feeling to a user, and that it can be quickly restored upon removal of load therefrom, that is, the three-dimensional structure has a high setting resistance.

[0048] Next, the cushion elements having a spring structure, which are all of Examples, and Comparative Examples 2 to 4, which are the conventional spring structures, are compared with each other. Comparative Example 2 has a

yield point, requires a high load relative to compression deflection, undergoes plastic deformation, and does not exhibit elastic recovery. Although Comparative Examples 3 and 4 do not have a yield point, a rise of load is recognized when the deflection ratio thereof exceeds 50 %, which means that they give a bottom touching feeling to a user. Further, they undergo plastic deformation, and does not exhibit elastic recovery.

- 5 [0049] If the compounding ratios between the resin materials and the bulk density are changed, it is possible to produce a cushion structure with desired hardness.

Test 2: Residual distortion after repeated compression

- 10 [0050] The test was carried out in conformity with the JIS K 6400 soft polyurethane foam-testing method 8.1A. The size of test pieces is 300(W) × 300(L) × 50(T).

[0051] The test was executed on the narrowed range of objects: Example 2 (PE + VAC, bulk density 0.03), Comparative Example 1, and Comparative Example 3 (PP, bulk density 0.03). Results of the tests are shown in Table 11.

15 Table 11

Results of measurement of residual distortion after repeated compression	
	Residual distortion after repeated compression (%)
Example 1	93
Comparative Example 1	95
Comparative Example 3	75

- 20 [0052] Example 1 and Comparative Example 1 show that they have the same level of performance. Although Example 2 and Comparative Example 3 have the same structure and are different only in resin, the residual distortion of Comparative Example 3 which undergoes plastic deformation is sharply reduced to 75 %. The resin molded article according to the invention has the same level of setting resistance as that of a polyurethane foam.

25 Test 3: Impact resilience

- 30 [0053] The test was carried out in conformity with the JIS K 6400 soft polyurethane foam-testing method 9.2B. The size of a test piece is 300 (W) × 300 (L) × 50 (T). Objects of the test are the same as Test 2. Results of the test are shown in Table 12.

35 Table 12

Measurement results of impact resilience ratios	
	Impact resilience (%)
Example 1	91
Comparative Example 1	65
Comparative Example 3	70

- 40 [0054] The resin molded article according to the invention has impact resilience 1.4 times as high as that of a polyurethane foam.

[0055] Although it is difficult to recycle a polyurethane foam, the resin molded article according to the invention can be regenerated into a product after it is used and hence it is excellent in recyclability.

- 45 [0056] The resin molded article according to the invention can be manufactured at reduced costs since recycled resins can be used for producing the same.

[0057] The resin molded article does not give a bottom touching sense, and has a very small quantity of local sinkage, thereby making it possible to uniformly receive load on a whole region in contact with the cushion structure. Hence, the article causes less fatigue of the user than a polyurethane foam.

- 50 [0058] Since the resin molded article according to the invention has a structure having completely continuous voids, it is more excellent in air permeability than a polyurethane foam.

- 55 [0059] Although in manufacturing the polyurethane foam, toxic materials, such as TDI and the like, are used, the resin molded article of the present invention can be produced without generating toxic gases and hence ensures good working conditions.

[0060] According to the invention, it is possible to recycle regenerated resins with high added values.

[0061] Thus, the broadest claims that follow are not directed to a machine that is configuration a specific way. Instead, said broadest claims are intended to protect the heart or essence of this breakthrough invention. This invention is clearly new and useful. Moreover, it was not obvious to those of ordinary skill in the art at the time it was made, in view of the prior art when considered as a whole.

[0062] Moreover, in view of the revolutionary nature of this invention, it is clearly a pioneering invention. As such, the claims that follow are entitled to very broad interpretation as to protect the heart of this invention, as a matter of law.

[0063] It will thus be seen that the objects set forth above, and those made apparent from the foregoing description, are efficiently attained. Also, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matters contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

[0064] It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween. Now that the invention has been described;

#### EXPLANATION OF REFERENCE NUMERALS

[0065]

- 20 10: an extruder
- 11: a hopper
- 12: a molding die
- 13: a winder
- 14: feed rollers
- 25 15: a bath
- 16: take-up rollers
- A: a low density portion
- B: a high density portion
- 19: a cutting device
- 30 25: a water supply valve
- 26: a drainage valve
- 30: resin molded article having a spring structure

#### 35 Claims

1. A resin molded article having a spring structure, comprising a three-dimensional structure with voids at a predetermined bulk density, said three-dimensional structure being formed by contacting, entwining, and gathering adjacent ones of random loops or curls of solid and/or hollow continuous filaments and/or short filaments made from a mixture of a polyolefin resin and VAC, EVA or SBS, wherein said three-dimensional structure is increased in bulk density in a direction of width thereof, at appropriate space intervals in a direction of length thereof.
2. The resin molded article according to claim 1, wherein said three-dimensional structure has voids providing low and high densities.
- 45 3. The resin molded article according to claim 1 or 2, a mixture ratio of said polyolefin resin to said VAC or said EVA is 70 to 97 wt% to 3 to 30 wt%, preferably, 80 to 90 wt% to 10 to 20 wt%.
4. The resin molded article according to any one of claims 1 to 3, wherein a mixture ratio of said polyolefin resin to said SBS is 50 to 97 wt% to 3 to 50 wt%, preferably, 70 to 90 wt% to 10 to 30 wt%.
- 50 5. The resin molded article according to claim 1 or 2, wherein said solid continuous filaments and/or short filaments have a diameter of 0.3 mm to 3.0 mm, preferably 0.7 to 1.0 mm, and said hollow continuous filaments and/or short filaments have a diameter of 1.0 mm to 3.0 mm, preferably 1.5 to 2.0 mm.
- 55 6. The resin molded article according to any one of claims 1 to 5, wherein said three-dimensional structure has a bulk density of 0.001 to 0.08 g/cm<sup>3</sup>, preferably 0.02 to 0.06 g/cm<sup>3</sup>.

7. The resin molded article according to any one of claims 1 to 6, wherein said three-dimensional structure is a cushion material for seats of an automotive vehicle or a bed.
- 5        8. A method of producing a resin molded article having a spring structure, by melt-extruding a polyolefin resin into a plurality of filaments, and contacting, entwining and gathering adjacent ones of random loops or curls of continuous filaments, thereby forming a three-dimensional structure with voids at a predetermined bulk density, wherein a take-off speed for taking off the extruded continuous filaments is changed to thereby form high density portions having an increased bulk density which each extend in a direction of width of said three-dimensional structure and are arranged at appropriate space intervals in a direction of length of said three-dimensional structure.
- 10      9. The resin molded article according to any one of claims 1 to 5, wherein said three-dimensional structure has a bulk density of 0.005 to 0.03 g/cm<sup>3</sup>, preferably 0.008 to 0.03 g/cm<sup>3</sup>, particularly preferably 0.01 to 0.03 g/cm<sup>3</sup> at low density portions, and a bulk density of 0.03 to 0.08 g/cm<sup>3</sup>, preferably 0.04 to 0.07 g/cm<sup>3</sup>, particularly preferably 0.05 to 0.06 g/cm<sup>3</sup> at high density portions.
- 15      10. The resin molded article according to claim 9, wherein said three-dimensional structure has a void ratio of 96 to 99 %, preferably 97 to 99 %, and particularly preferably 97 to 98 % at said low density portions, and a void ratio of 91 to 97 %, preferably 92 to 96 %, and particularly preferably 93 to 94 % at said high density portions.
- 20      11. The resin molded article according to any one of claims 1 to 5, wherein a mixture ratio of solid filaments to hollow filaments is 0 to 50 to 50 to 100.
- 25      12. The resin molded article according to any one of claims 1 to 5, wherein outer surfaces of said hollow filaments are covered with solid filaments.

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# FIG. 1

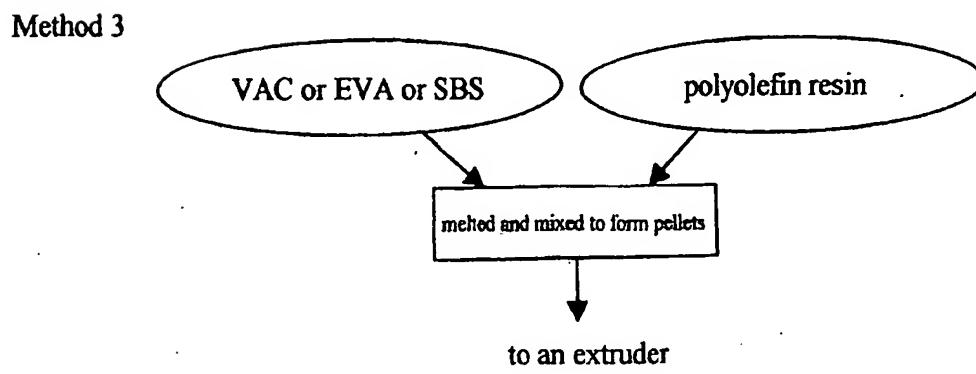
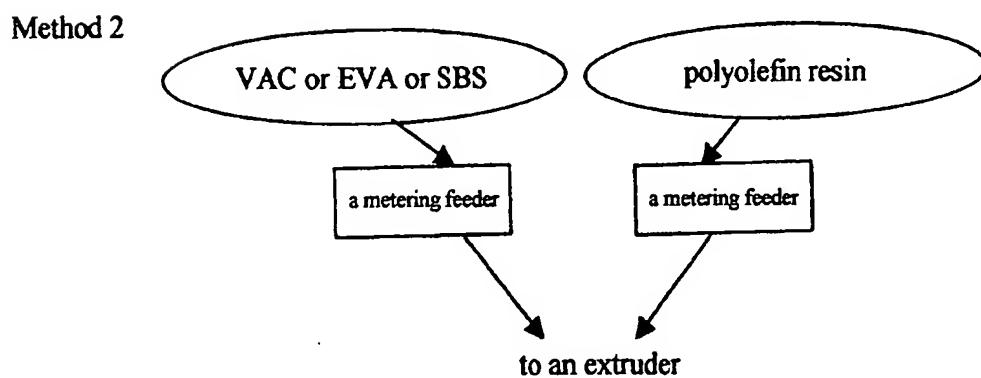
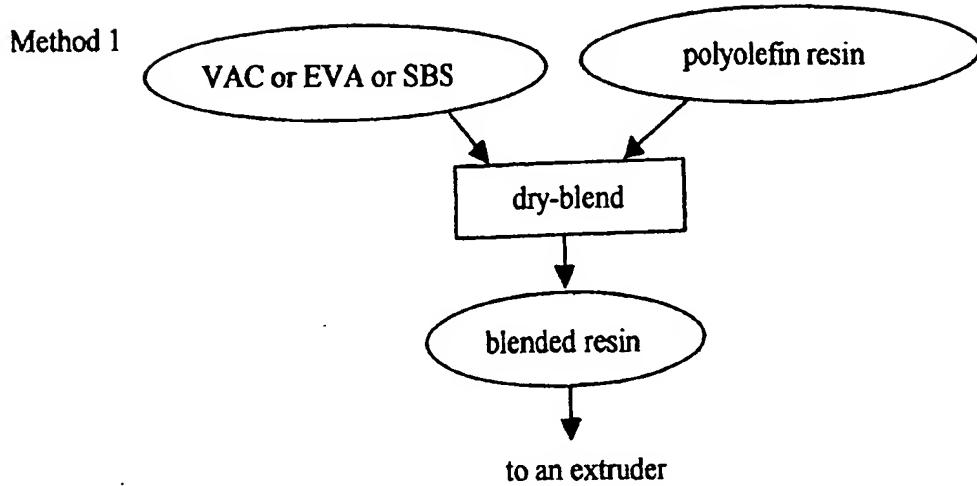
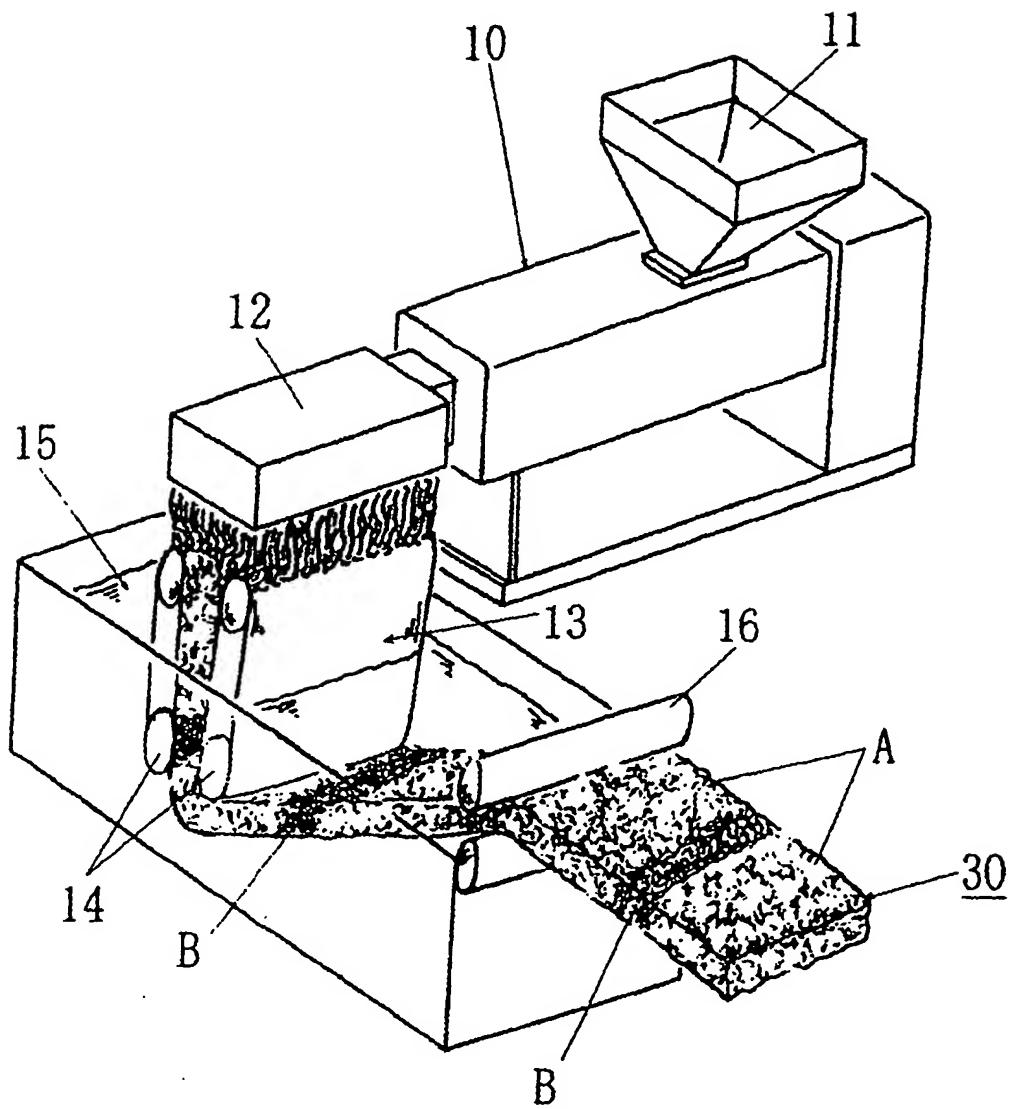


FIG. 2



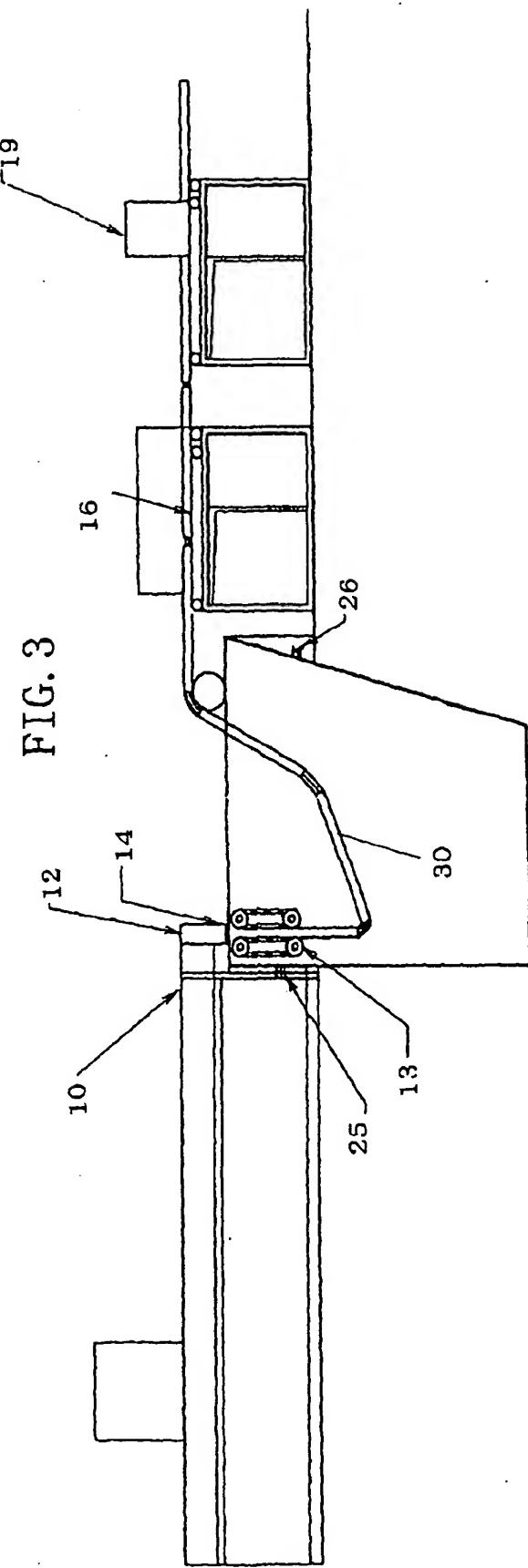


FIG. 4

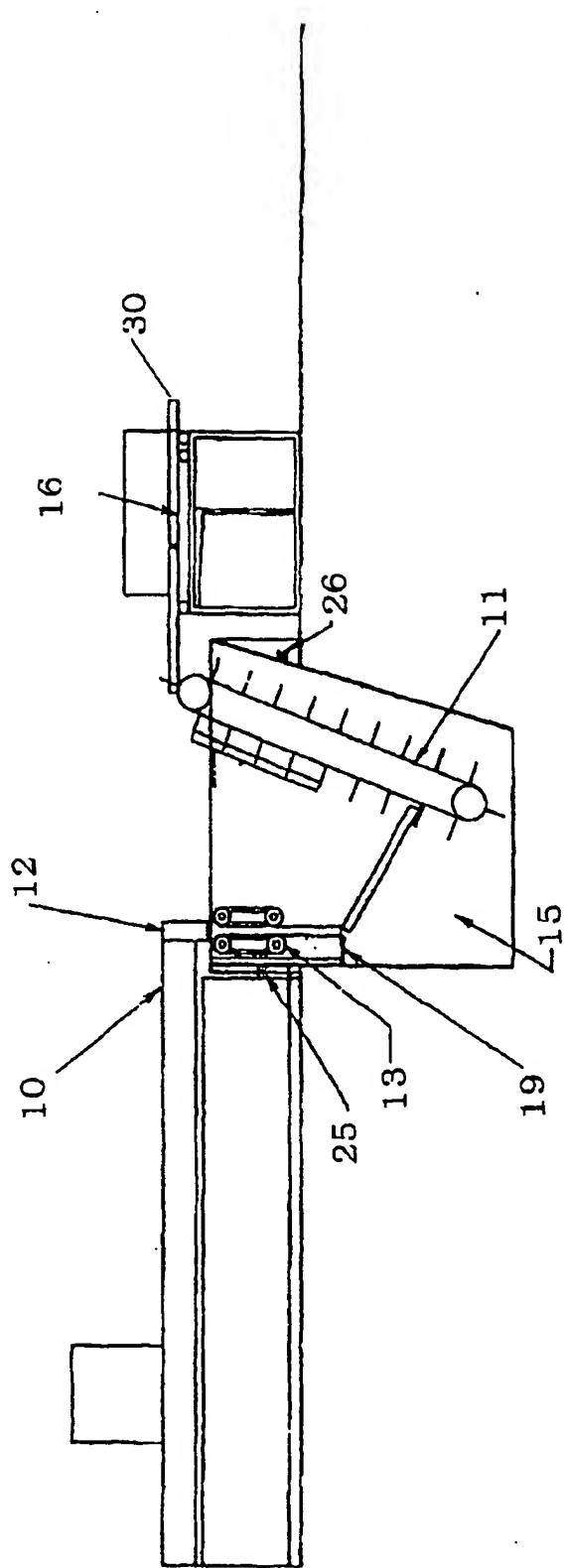
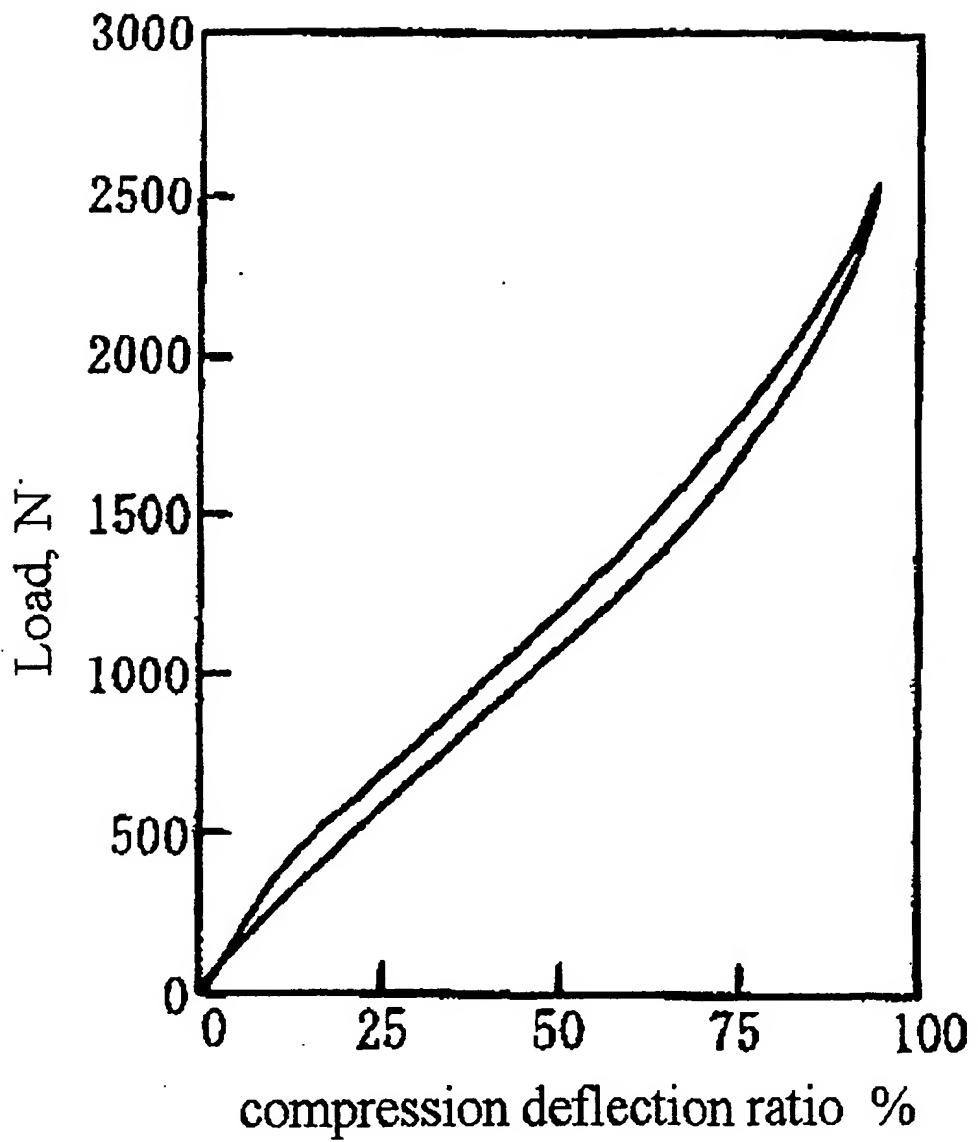
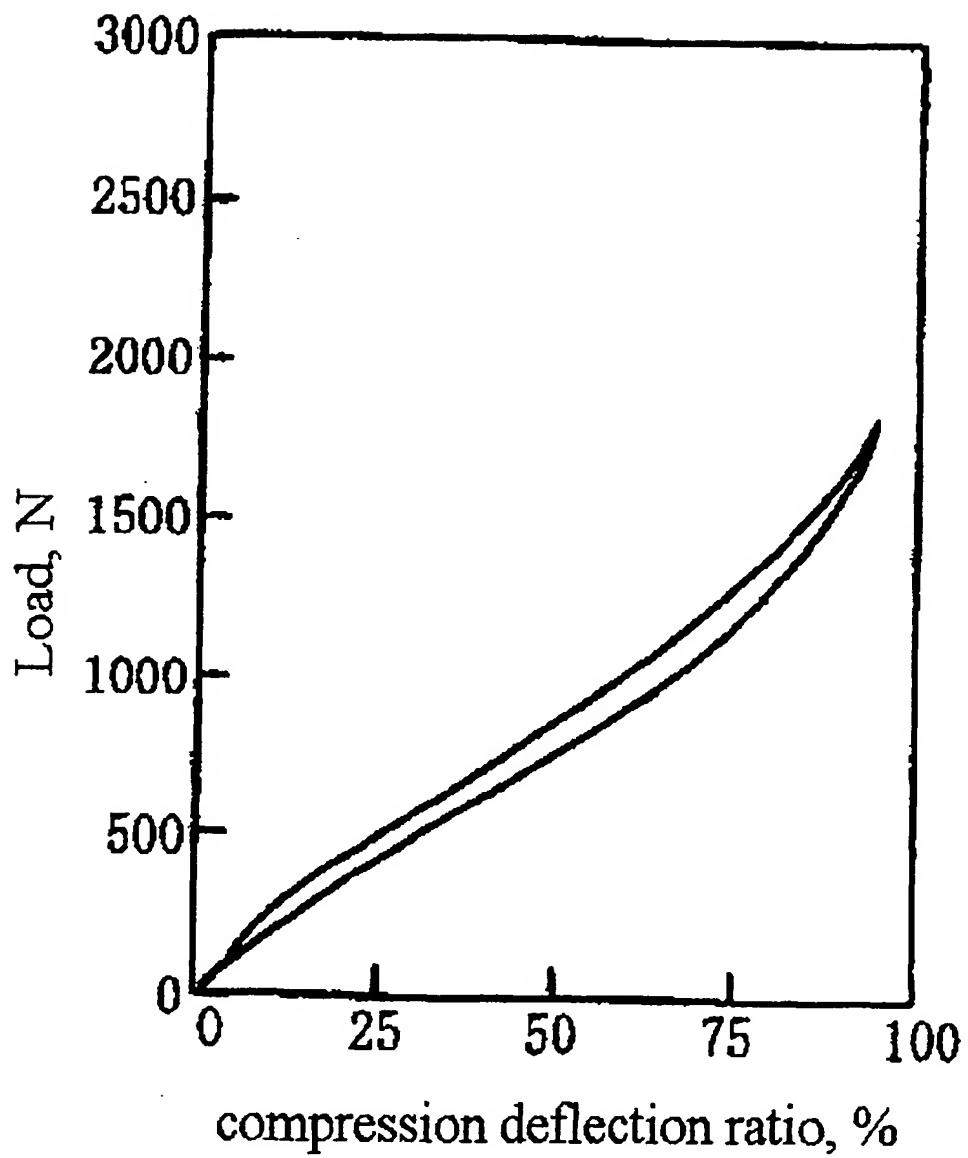


FIG. 5



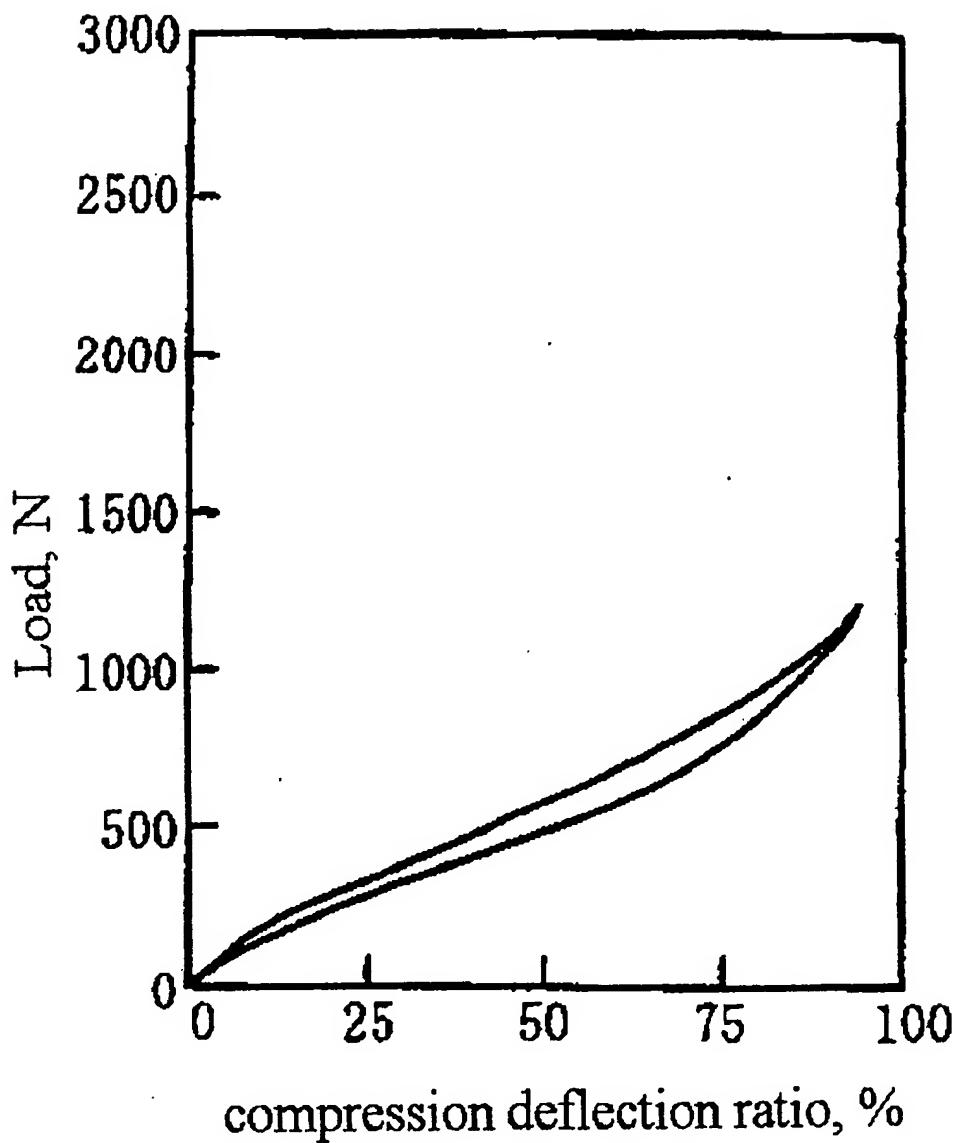
Example 1

FIG. 6



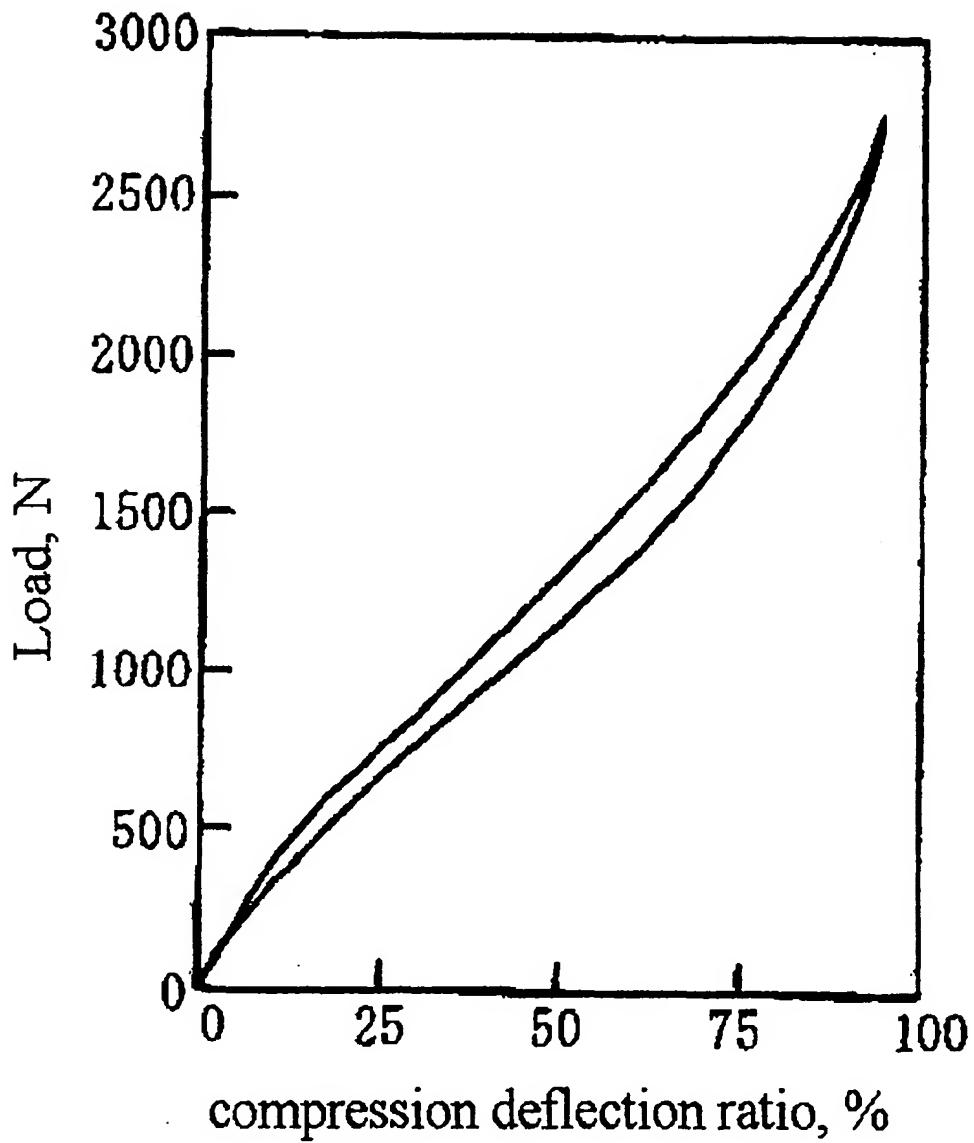
Example 2

FIG. 7



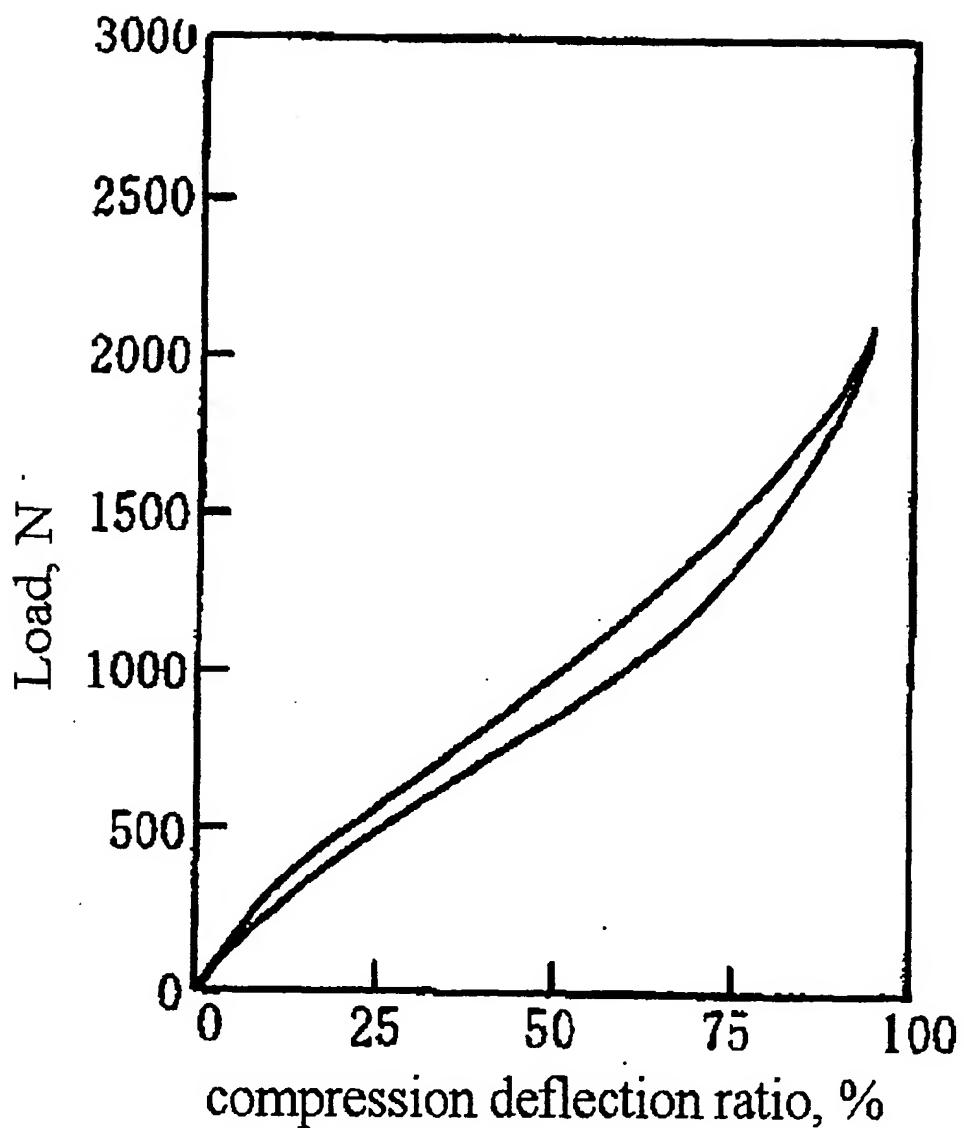
Example 3

FIG. 8



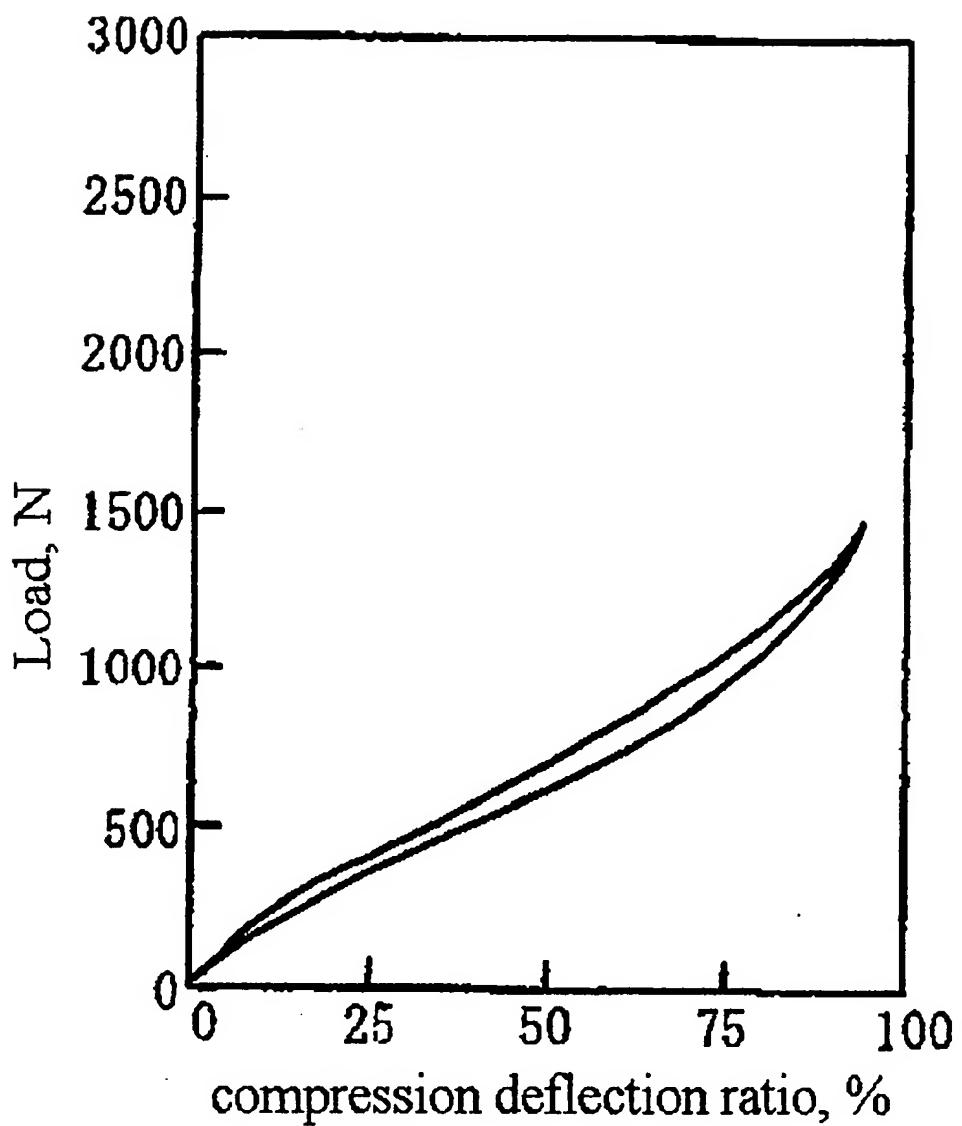
Example 4

FIG. 9



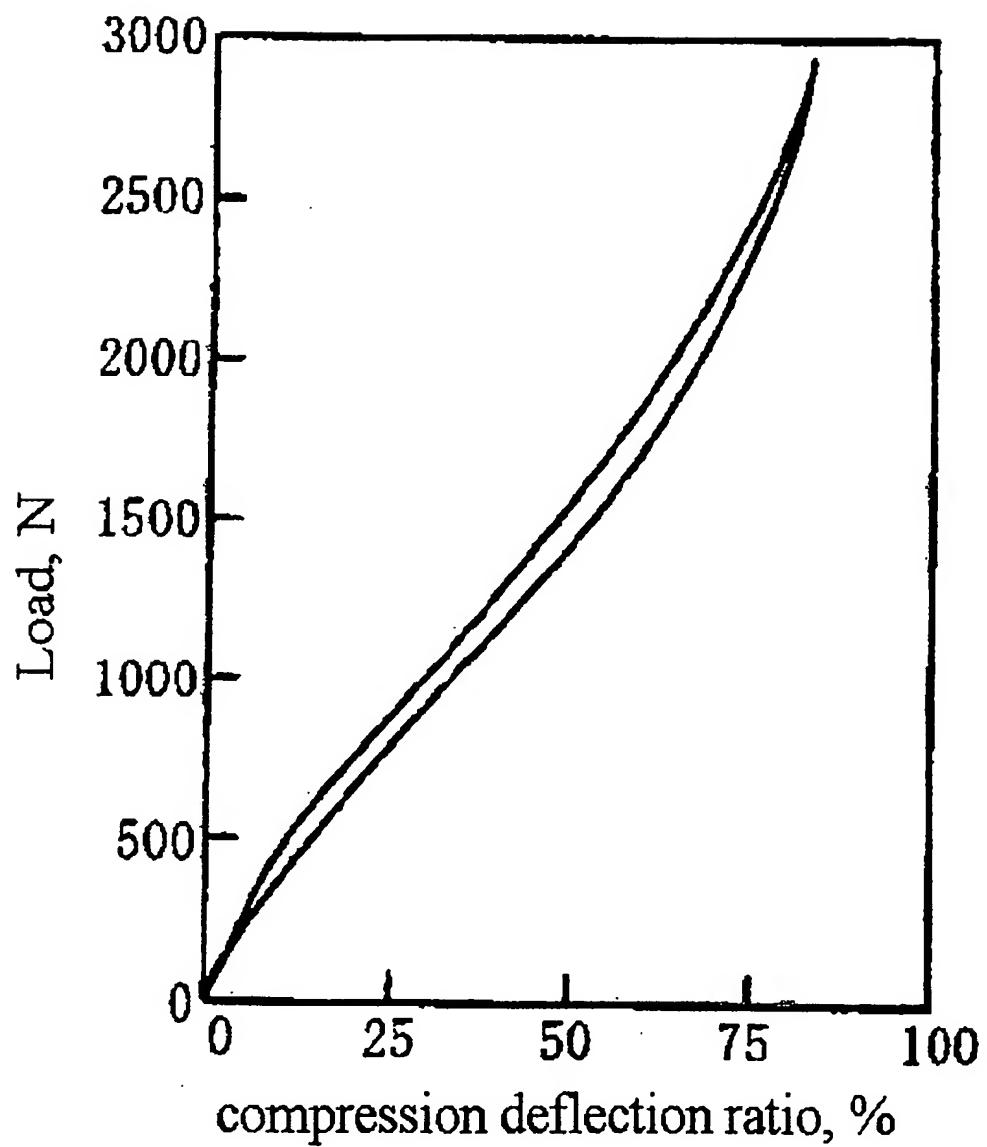
Example 5

FIG. 10



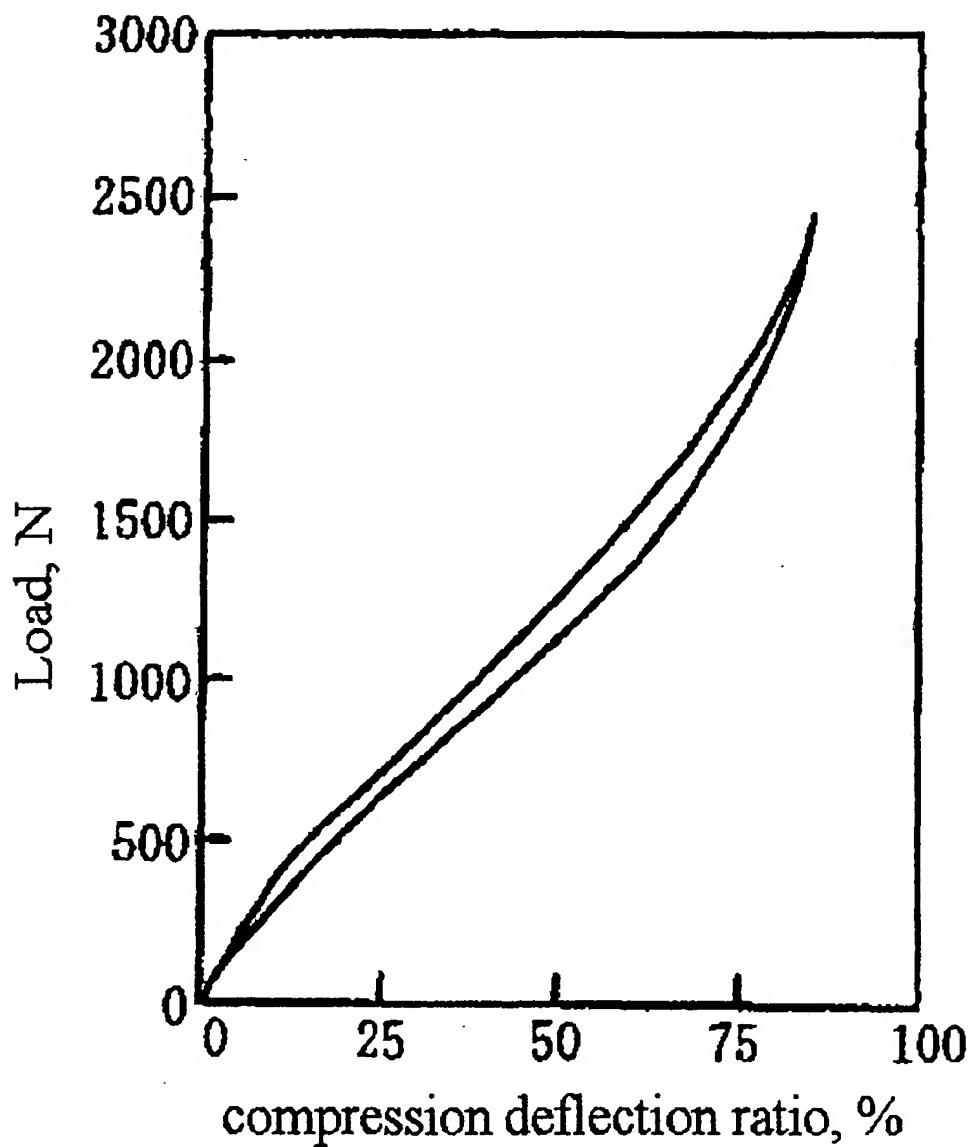
Example 6

FIG. 11



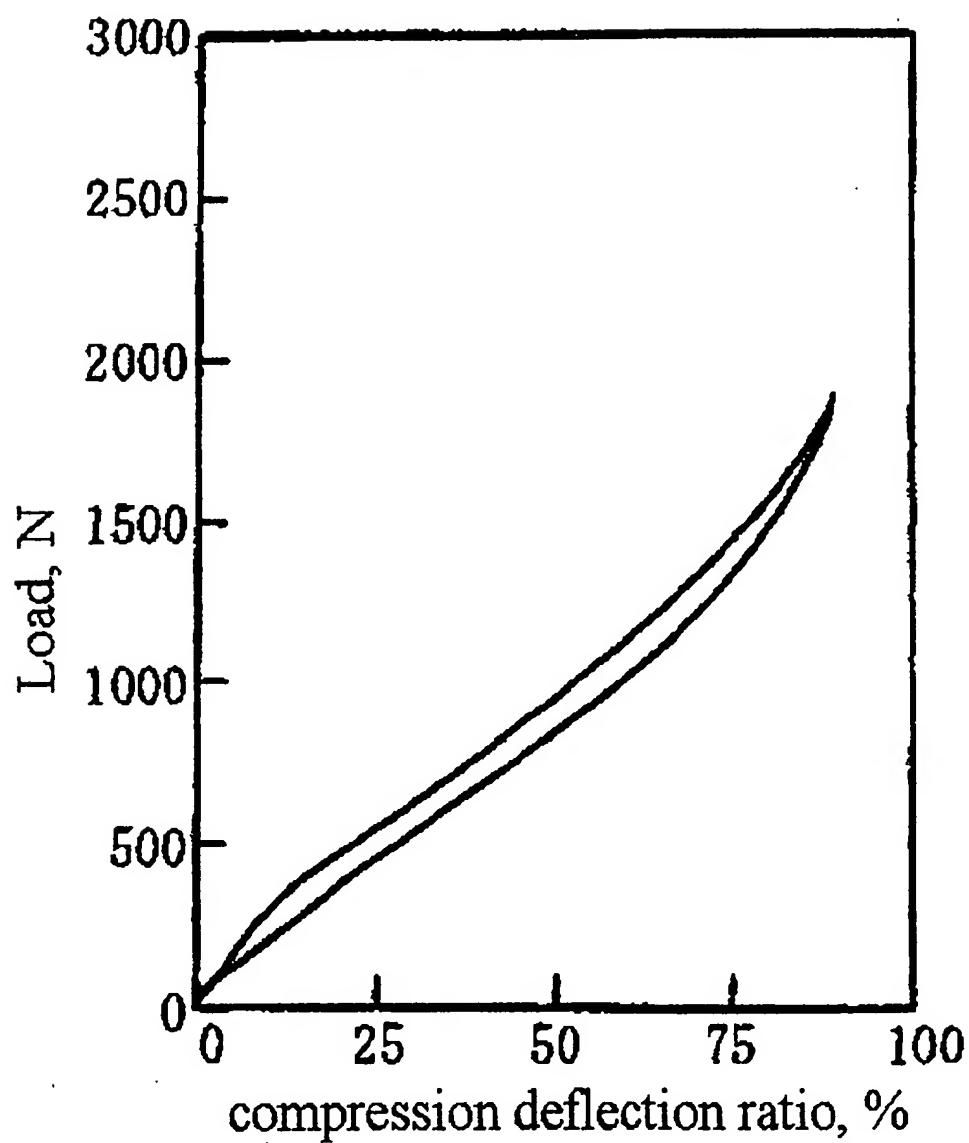
Example 7

FIG. 12



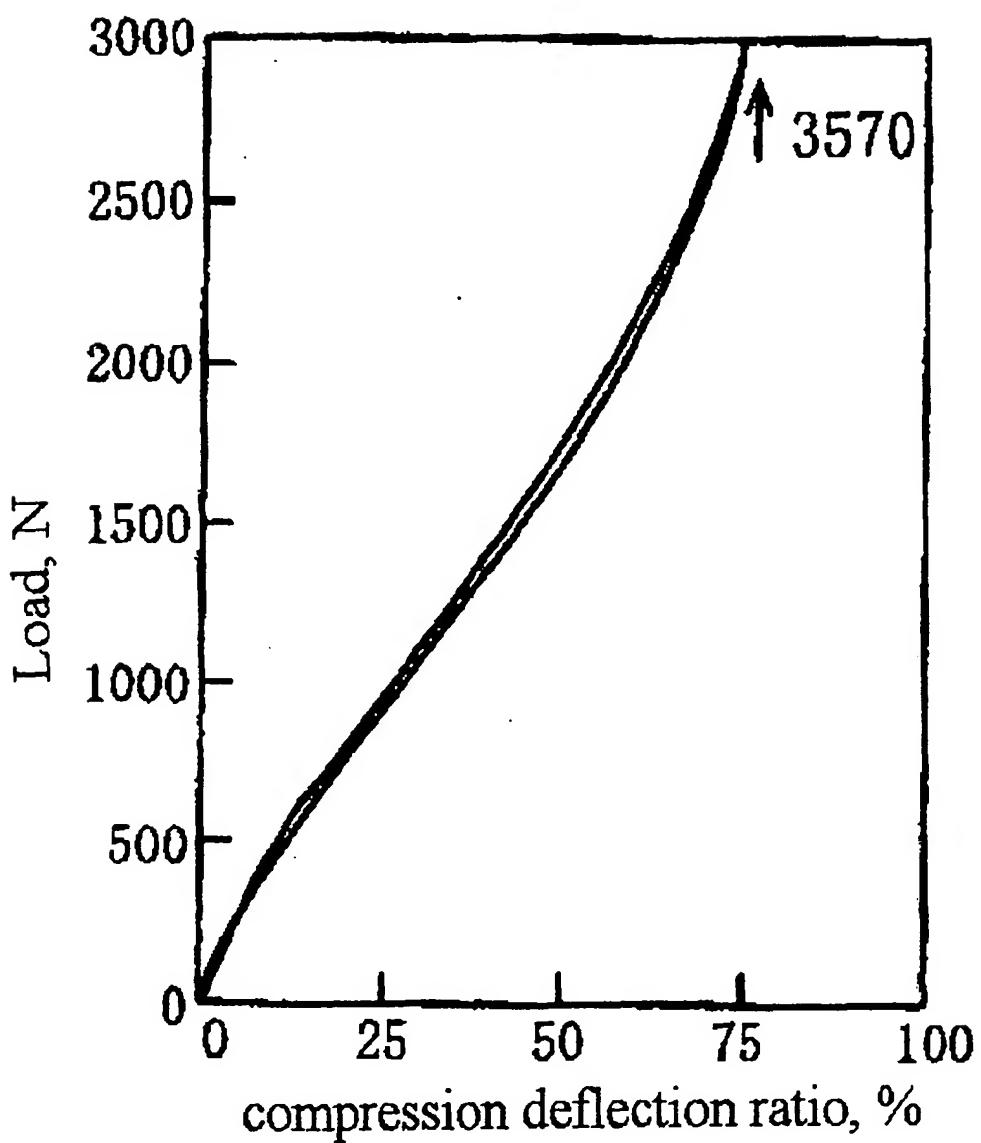
Example 8

FIG. 13



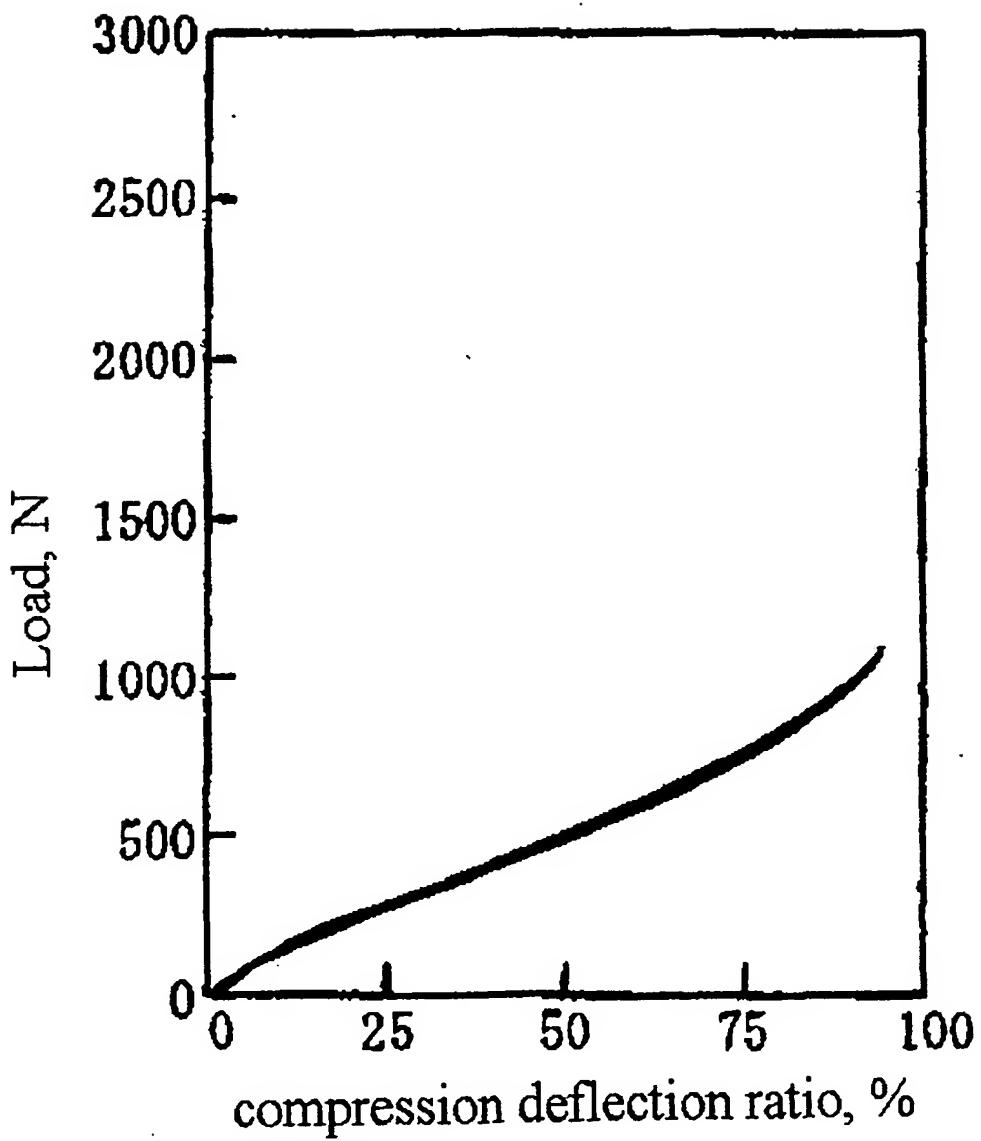
Example 9

FIG. 14



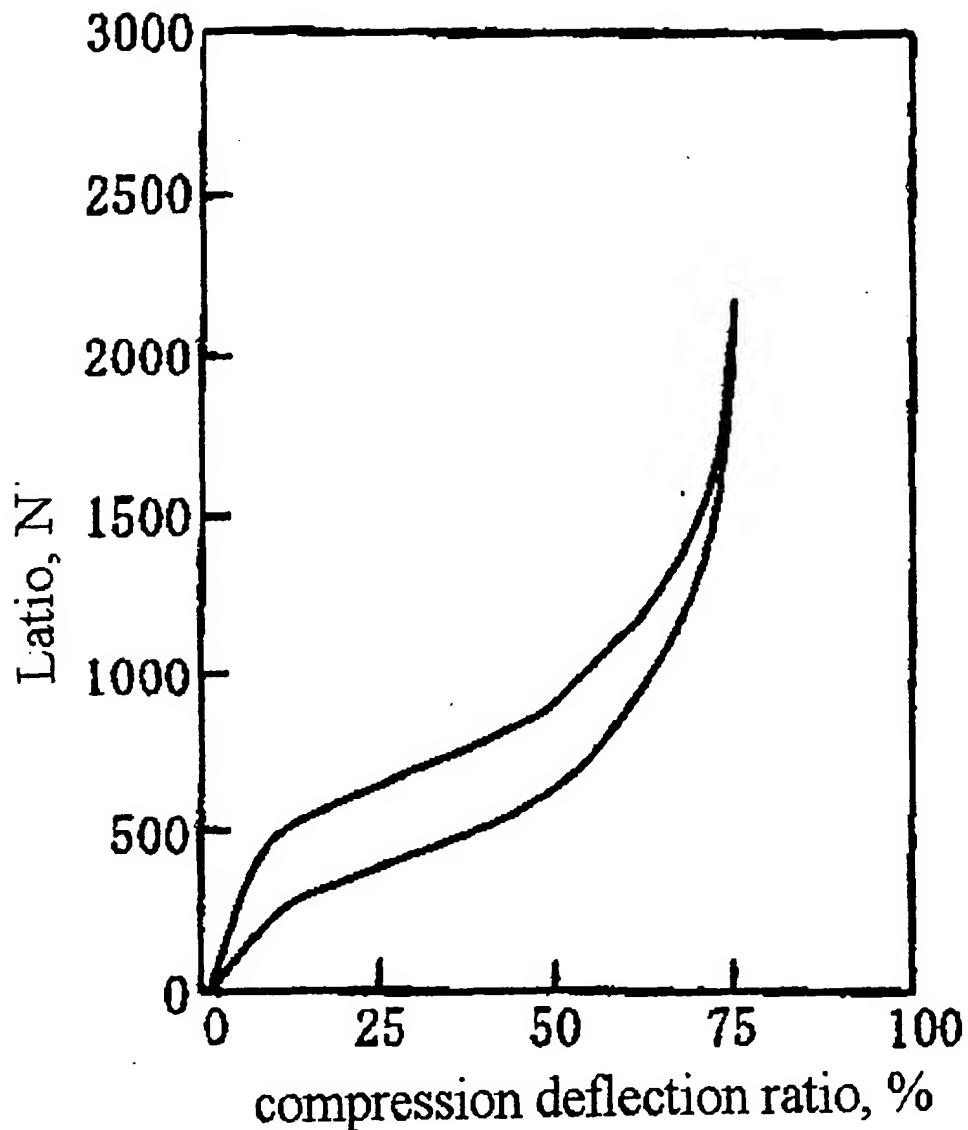
Example 10

FIG. 15



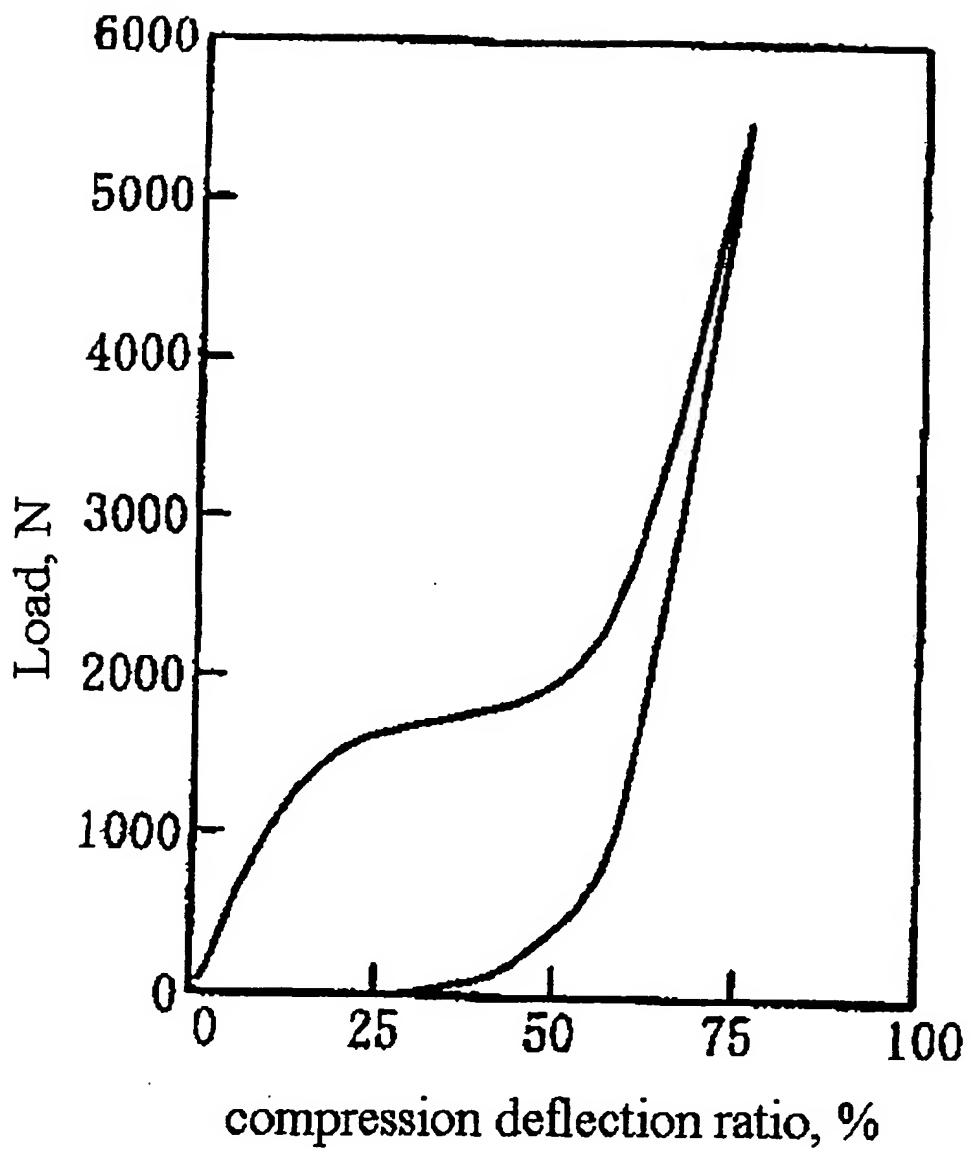
Example 11

FIG. 16



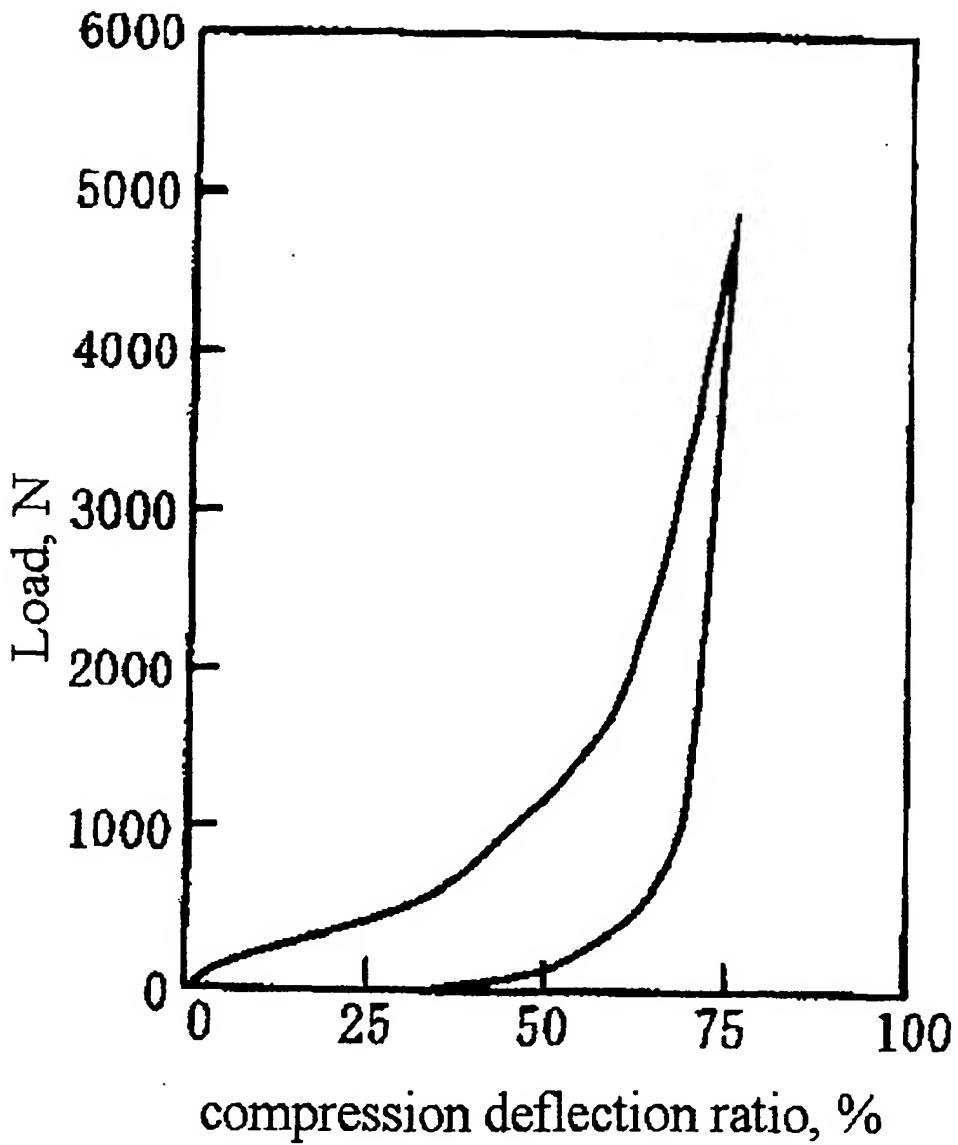
Comparative Example 1

FIG. 17



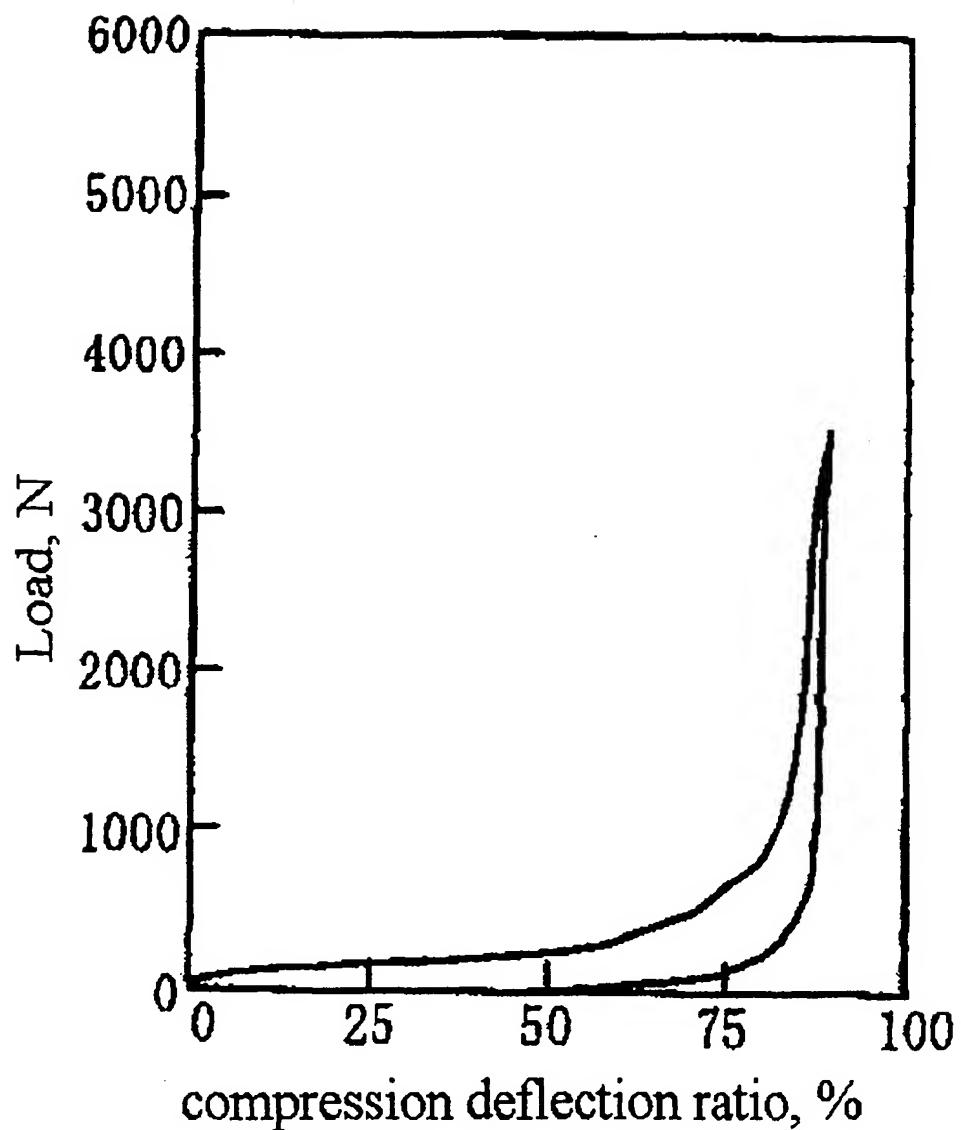
Comparative Example 2

FIG. 18



Comparative Example 3

FIG. 19



Comparative Example 4



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 01 85 0141

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Place of search	Date of completion of the search	Examiner			
MUNICH	28 November 2001	Foulger, C			
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